DETAILED DESCRIPTION OF THE INVENTION

The first embodiment of this method and invention is a single pump system for measuring and dispensing single liquids and mixtures of liquids in precise, accurately measured volumes. This system, shown in FIG. 1, consists of a syringe pump **2**, a valve manifold **4** (with multiple valves) and an air valve **6**. The valve manifold contains valves **12** and **42**, several supply lines or conduits **14**, an outlet or dispensing line/nozzle or conduit **16**, and a line or conduit leading to a syringe pump **18**. It will become apparent that only a single supply line is required although multiple supply lines are particularly well served by this invention. The syringe pump **2** is comprised of a cylinder or cavity **22**, piston or member **24**, and a means to displace the piston within the cylinder such as a lead screw **26** and stepper motor **28**. The piston **24** may have at least one o-ring **30** partially contained inside a groove **32** around its circumference, which seals with the cylinder **22**. The piston **24** may also have two o-rings or other suitable seal for improved sealing. Displacement of the piston **24** inside the cylinder **22** changes the volume of the chamber formed by the cylinder end, wall, and piston bottom. The piston contains a hollow passage or conduit **34** which leads from the inside of the chamber to an air valve **6**. The piston **24** and cylinder **22** are oriented so that the mouth of the passage **34** within the piston **24** is located at the highest practical point within the variable volume chamber, thus allowing air to escape from the chamber. The outlet of the air valve is open to the atmosphere or a body of gas **36**. Air valve liquid sensing device or detector **38** is located on either side of the air valve **6.** Dispense valve liquid sensing device or detector **40** is located on either side of the dispense valve. All components are connected with appropriately sized tubing.

This system is specifically designed to have a minimal internal volume when the syringe piston **24** is fully inserted into the cylinder **22**. This is intended to reduce the amount of air initially present in the system. The location, size, and arrangement of the internal passages of this system are such that at one specified volume (such as 10mL) the system can accurately measure the volume of a liquid regardless of that liquid's density or vapor pressure. This measured volume remains accurate regardless of which supply line **14** and valve **12** are used.

To begin the volume measurement process, the system starts with the syringe pump piston **24** at the bottom of its stroke as shown in FIG. 1. This eliminates most of the air in the system. Next, the desired supply line valve **12** is opened and the syringe piston

24 is displaced upward (away from the bottom of the cylinder **22**) a known distance, as shown in FIG. 2. This movement of the syringe draws a volume of liquid **44** into the system from the supply line **14**. The supply line valve **12** is then closed and the air valve **6** leading from the syringe piston **24** is opened. The syringe piston **24** is then displaced downward, as shown in FIG. 3, forcing the liquid in the system through the tubing **34** leading to the air valve **6**. Using a liquid sensing device **38** to sense the position of the liquid, the liquid is pushed just past the air valve **6** and the valve is closed. This procedure removes the air from inside the syringe pump **2**. Next, the dispense line valve **42** is opened. The syringe piston **24** is once again displaced in the downward direction, as shown in FIG. 4, pushing the liquid just past the dispense valve **42** sensing the position of the liquid using liquid sensing device **40**. The dispense valve **42** is then closed. This procedure removes the air from inside the valve manifold **4**. At this point in the process there is no air in the system, only liquid. The volume of liquid is known by virtue of the position of the piston **24** in the syringe pump **2** and the known volumes of the valve manifold **4**, conduits **18**, and hollow passage **34**. The supply line valve **12** is then opened. The syringe piston **24** is then displaced upward a known distance that will result in the intake of the desired volume of liquid **48**, as shown in FIG. 5. After the piston **24** has been displaced, the system pauses to allow any cavitation to subside. The supply valve **12** is then closed. At this stage the system contains the exact desired volume of a specified liquid. This correct volume is then expelled into an appropriate container **50** by opening the dispense line valve **42** and displacing the syringe piston **24** fully downward, as shown in FIG. 6. The dispense line valve **42** is then closed and the air valve **6** is opened. The piston **24** is retracted upward fully, drawing in a full volume of air. The air valve **6** is then closed. The dispense line valve **42** is once again opened and the syringe piston **24** is displaced fully downward, expelling the remaining liquid. This purging process can be repeated as many times as necessary to expel any residual liquid thereby producing the required precision for volume measurement.

An alternate embodiment of this device, shown in FIG. 7, is created by adding a secondary pump **52**, another valve **54**, and another liquid sensing device or detector **56**. The initial air removal step, as shown in FIG. 8, is achieved through the use of the secondary pump **52**. This is accomplished by first opening the supply valve **12**, and then opening the secondary pump valve **56**. The secondary pump **52** is then operated until the liquid has been detected by the secondary pump liquid sensing device or detector **56**. At this point, both the supply valve **12** and secondary pump valve **54** are closed. The remaining unwanted air is removed through the use of the main syringe pump **2** as

shown in FIG. 9. The dispense valve **42** is opened and the syringe pump piston **24** is displaced downward until the liquid is pushed past the dispense valve **42** and detected by the dispense valve liquid sensing device **40**. From this point, the volume measurement and dispense procedure are conducted in the same manner as the previous embodiment.

Another embodiment of this device is shown in FIG. 10. As with the previous embodiment, a secondary pump **52** is added to the system. The dispensing and volume measurement procedure for this device begins with the piston **24** fully inserted into the cylinder **22**. Next, secondary pump valve **54** is opened while all other valves remain closed. Secondary pump **52** is then activated to remove the air from the system by creating a vacuum. Once a vacuum exists in the system, secondary pump valve **54** is then closed and secondary pump **52** is deactivated. With the system still under vacuum, supply valve **12** is opened, filling the system with liquid. From this point, the volume measurement and dispense procedure are conducted in the same manner as the first embodiment.

Those skilled in the art will appreciate that various adaptations and modifications of the just-described preferred embodiments can be configured without departing from the scope and spirit of the invention. For example, operations may be performed in a different order to achieve an identical result or the hollow passage located in the piston might be located in the cylinder wall instead. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.